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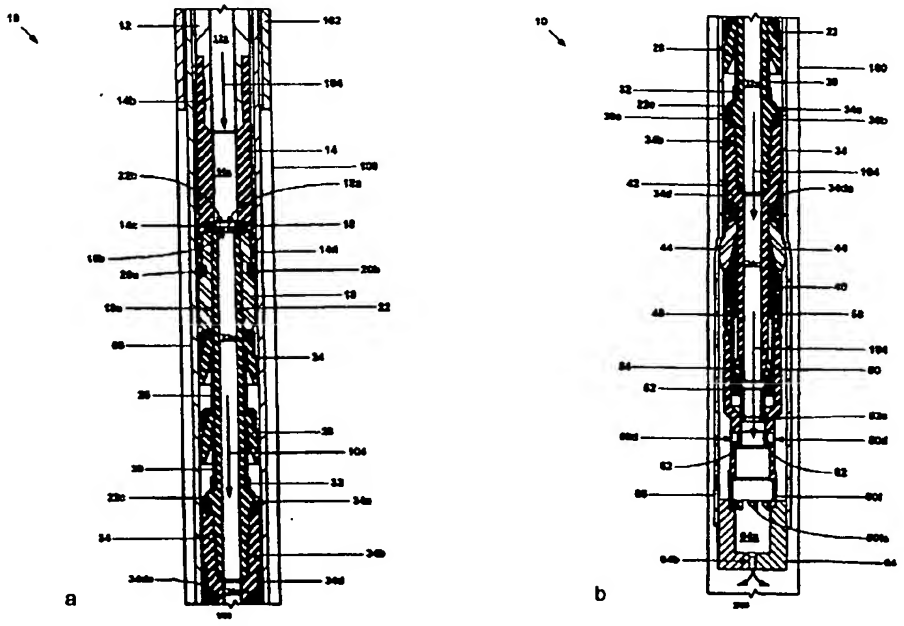
(54) Title: COLLAPSIBLE EXPANSION CONE



(57) Abstract: An apparatus (910) for radially expanding and plastically deforming an expandable tubular member (66) includes a collapsible expansion cone (44, 46).

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US03/18530

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : E21B 43/10
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 166/207,217,382,121,212,216,387

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3,691,624 A (KINLEY) 19 September 1972 (19/09/1972), see especially Figure 1-3 and columns 3 and 4.	26, 29
A	US 3,631,926 A (YOUNG) 04 January 1972 (04/01/1972), see fig. 1.	30-33

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

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"P" document published prior to the international filing date but later than the priority date claimed

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (703) 305-3230	Authorized officer WILLIAM P. NEUDER Telephone No. (703) 308-2150

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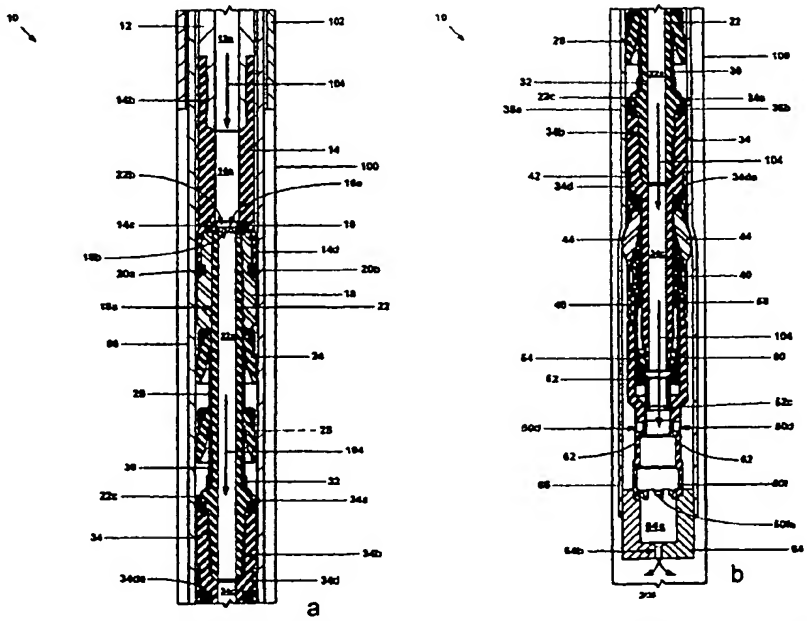
(54) Title: COLLAPSIBLE EXPANSION CONE



(57) Abstract: An apparatus (910) for radially expanding and plastically deforming an expandable tubular member (66) includes a collapsible expansion cone (44, 46).

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AMENDED CLAIMS
[received by the International Bureau on 20 August 2004 (20.08.04);
original claims 26, 29, 40 and 42 amended; claims 44-49 added ,
remaining claims unchanged (6 pages)].

an intermediate portion defining arcuate cylindrical and spherical upper surfaces and an arcuate conical lower surface; and

an outer portion defining arcuate cylindrical upper and lower surfaces;

wherein each upper expansion cone segment is tapered in the longitudinal direction from the intermediate portion to the outer portion; and

wherein each lower expansion cone segment is tapered in the longitudinal direction from the intermediate portion to the outer portion.

26. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

a tubular support member;

a collapsible expansion cone coupled to the tubular support member;

an expandable tubular member coupled to the collapsible expansion cone;

means for displacing the collapsible expansion cone relative to the expandable tubular member using fluid pressure; and

means for collapsing the expansion cone.

27. The apparatus of claim 26, wherein the tubular support member comprises an upper tubular support member comprising an internal flange and a lower tubular support member comprising an internal flange; wherein the expansion cone comprises:

an upper cam assembly coupled to the upper tubular support member comprising:

a tubular base coupled to the upper support member; and

a plurality of cam arms extending from the tubular base in a downward longitudinal direction, each cam arm defining an inclined surface;

a plurality of upper expansion cone segments interleaved with the cam arms of the upper cam assembly and pivotally coupled to the internal flange of the upper tubular support member;

a lower cam assembly coupled to the lower tubular support member comprising:

a tubular base coupled to the lower tubular support member; and

a plurality of cam arms extending from the tubular base in an upward longitudinal direction, each cam arm defining an inclined surface that mates with the inclined surface of a corresponding one of the upper expansion cone segments;

wherein the cams arms of the upper cam assembly are interleaved with and overlap the cam arms of the lower cam assembly; and

a plurality of lower expansion cone segments interleaved with cam arms of the lower cam assembly, each lower expansion cone segment pivotally coupled to the internal flange

of the lower tubular support member and mating with the inclined surface of a corresponding one of the cam arms of the upper cam assembly; and wherein the apparatus further comprises:

means for releasably coupling the upper tubular support member to the lower tubular support member; and

means for limiting movement of the upper tubular support member relative to the lower tubular support member.

28. The apparatus of claim 26, further comprising:

means for pivoting the upper expansion cone segments; and

means for pivoting the lower expansion cone segments.

29. The apparatus of claim 26, further comprising:

means for pulling the collapsible expansion cone through the expandable tubular member using fluid pressure.

30. A collapsible expansion cone, comprising:

an upper cam assembly comprising:

a tubular base; and

a plurality of cam arms extending from the tubular base in a downward longitudinal direction, each cam arm defining an inclined surface;

a plurality of upper expansion cone segments interleaved with the cam arms of the upper cam assembly;

a lower cam assembly comprising:

a tubular base; and

a plurality of cam arms extending from the tubular base in an upward longitudinal direction, each cam arm defining an inclined surface that mates with the inclined surface of a corresponding one of the upper expansion cone segments;

wherein the cams arms of the upper cam assembly are interleaved with and overlap the cam arms of the lower cam assembly;

a plurality of lower expansion cone segments interleaved with cam arms of the lower cam assembly, each lower expansion cone segment mating with the inclined surface of a corresponding one of the cam arms of the upper cam assembly;

means for moving the upper cam assembly away from the lower expansion cone segments; and

means for moving the lower cam assembly away from the upper expansion cone segments.

31. The apparatus of claim 30, wherein the upper and lower expansion cone segments together define an arcuate spherical external surface.

32. The apparatus of claim 30, wherein each upper expansion cone segment comprises:

an inner portion defining an arcuate cylindrical upper surface and arcuate cylindrical lower surfaces;

an intermediate portion defining arcuate cylindrical and spherical upper surfaces and an arcuate conical lower surface; and

an outer portion defining arcuate cylindrical upper and lower surfaces; and

wherein each lower expansion cone segment comprises:

an inner portion defining an arcuate cylindrical upper surface and arcuate cylindrical lower surfaces;

an intermediate portion defining arcuate cylindrical and spherical upper surfaces and an arcuate conical lower surface; and

an outer portion defining arcuate cylindrical upper and lower surfaces.

33. The apparatus of claim 30, wherein each upper expansion cone segment is tapered in the longitudinal direction from the intermediate portion to the outer portion; and

wherein each lower expansion cone segment is tapered in the longitudinal direction from the intermediate portion to the outer portion.

34. A packer cup apparatus comprising:

a central mandrel,

a sealing cup comprising

a substantially unrestricted lip for sealing engaging a tubular member, and

a base portion for sealingly engaging the central mandrel,

a protecting member positioned longitudinally along the central mandrel,

a pliant backup member positioned between the protecting member and the sealing cup,

a conical bushing positioned partially between the sealing cup and the central mandrel for supporting the base portion of the sealing cup.

35. The apparatus of claim 34 wherein the pliant backup member is made from a material selected from the group consisting of fluropolymer, fluoroelastomer, Telflon, or PEEK.

36. The apparatus of claim 34 further comprising a restraining member surrounding the base portion of the sealing cup for restraining the sealing cup.

37. The apparatus of claim 34 wherein the protecting member is a thimble surrounding the base portion of the sealing cup.

38. The apparatus of claim 37 wherein the sealing cup further comprises an unsupported portion between the thimble and a point of engagement with the expandable tubular member, and a means for reducing the unsupported portion of the sealing cup.

39. A method of radially expanding and plastically deforming an expandable tubular member, comprising:

supporting the expandable tubular member using a tubular support member and a collapsible expansion cone;

injecting a fluidic material into the tubular support member;

sensing the operating pressure of the injected fluidic material within a first interior portion of the tubular support member;

displacing the collapsible expansion cone relative to the expandable tubular member when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the first interior portion of the tubular support member;

sensing the operating pressure of the injected fluidic material within a second interior portion of the tubular support member; and

collapsing the collapsible expansion cone when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the second interior portion of the tubular support member.

40. The method of claim 39, further comprising:

pulling the collapsible expansion cone through the expandable tubular member when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the first interior portion of the tubular support member.

41. The method of claim 40, wherein pulling the collapsible expansion cone through the expandable tubular member comprises:

coupling one or more cup seals to the tubular support member above the collapsible expansion cone;

pressuring the interior of the expandable tubular member below the cup seals; and

pulling the collapsible expansion cone through the expandable tubular member using the cup seals.

42. The method of claim 39, wherein the tubular support member comprises an upper tubular support member and a lower tubular support member; and wherein collapsing the collapsible expansion cone comprises displacing the upper tubular member relative to the lower tubular support member.

43. The method of claim 42, wherein the collapsible expansion cone comprises:

an upper cam assembly comprising:

a tubular base; and

a plurality of cam arms extending from the tubular base in a downward longitudinal direction, each cam arm defining an inclined surface;

a plurality of upper expansion cone segments interleaved with the cam arms of the upper cam assembly and pivotally coupled to the upper tubular support member;

a lower cam assembly comprising:

a tubular base; and

a plurality of cam arms extending from the tubular base in an upward longitudinal direction, each cam arm defining an inclined surface that mates with the inclined surface of a corresponding one of the upper expansion cone segments;

wherein the cams arms of the upper cam assembly are interleaved with and overlap the cam arms of the lower cam assembly; and

a plurality of lower expansion cone segments interleaved with cam arms of the lower cam assembly, each lower expansion cone segment pivotally coupled to the lower tubular support member and mating with the inclined surface of a corresponding one of the cam arms of the upper cam assembly.

44. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

a tubular support member;

a collapsible expansion device coupled to the tubular support member;

an expandable tubular member coupled to the collapsible expansion cone;

means for displacing the collapsible expansion device relative to the expandable tubular member using fluid pressure; and

means for collapsing the expansion cone.

45. The apparatus of claim 44, further comprising:

means for pulling the collapsible expansion device through the expandable tubular member using fluid pressure.

46. A method of radially expanding and plastically deforming an expandable tubular member, comprising:

supporting the expandable tubular member using a tubular support member and a collapsible expansion device;

injecting a fluidic material into the tubular support member;

sensing the operating pressure of the injected fluidic material within a first interior portion of the tubular support member;

displacing the collapsible expansion device relative to the expandable tubular member when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the first interior portion of the tubular support member;

sensing the operating pressure of the injected fluidic material within a second interior portion of the tubular support member; and

collapsing the collapsible expansion device when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the second interior portion of the tubular support member.

47. The method of claim 46, further comprising:

pulling the collapsible expansion device through the expandable tubular member when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the first interior portion of the tubular support member.

48. The method of claim 47, wherein pulling the collapsible expansion device through the expandable tubular member comprises:

coupling one or more cup seals to the tubular support member above the collapsible expansion device;

pressuring the interior of the expandable tubular member below the cup seals; and

pulling the collapsible expansion device through the expandable tubular member using the cup seals.

49. The method of claim 46, wherein the tubular support member comprises an upper tubular support member and a lower tubular support member; and wherein collapsing the collapsible expansion device comprises displacing the upper tubular member relative to the lower tubular support member.